Annual Energy Outlook 2000

With Projections to 2020

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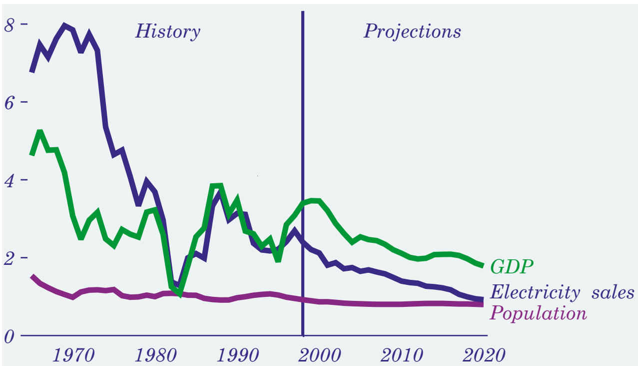
Parallel Growth Rates Are Projected for Electricity Use and GDP

Figure 66. Population, gross domestic product, and electricity sales, 1965-2020 (5-year moving average annual percent growth)



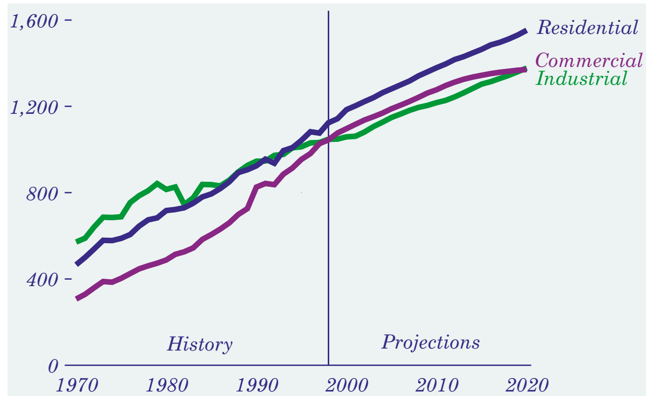
As generators and cogenerators try to adjust to the evolving structure of the electricity market, they also face slower growth in demand than in the past. Historically, the demand for electricity has been related to economic growth. That positive relationship is expected to continue, but the ratio is uncertain.

During the 1960s, electricity demand grew by more than 7 percent a year, nearly twice the rate of economic growth (Figure 66). In the 1970s and 1980s, however, the ratio of electricity demand growth to economic growth declined to 1.5 and 1.0, respectively. Several factors have contributed to this trend, including increased market saturation of electric appliances, improvements in equipment efficiency and utility investments in demand-side management programs, and more stringent equipment efficiency standards. Throughout the forecast, growth in demand for office equipment and personal computers, among other equipment, is dampened by slowing growth or reductions in demand for space heating and cooling, refrigeration, water heating, and lighting. The continuing saturation of electricity appliances, the availability and adoption of more efficient equipment, and efficiency standards are expected to hold the growth in electricity sales to an average of 1.4 percent a year between 1998 and 2020, compared with 2.2-percent annual growth in GDP.

Changing consumer markets could mitigate the slowing of electricity demand growth seen in these projections. New electric appliances are introduced frequently. If new uses of electricity are more substantial than currently expected, they could offset future efficiency gains to some extent.

Continued Growth in Electricity Use Is Expected in All Sectors

Figure 67. Annual electricity sales by sector, 1970-2020 (billion kilowatthours)



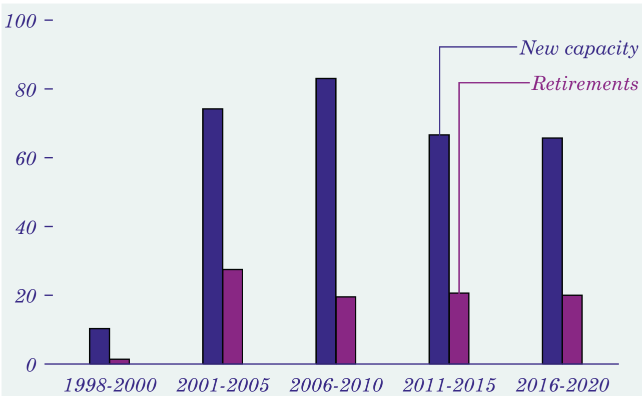
With the number of U.S. households projected to rise by 1.0 percent a year between 1998 and 2020, residential demand for electricity grows by 1.5 percent annually (Figure 67). Residential electricity demand changes as a function of the time of day, week, or year. During summer, residential demand peaks in the late afternoon and evening, when household cooling and lighting needs are highest. This periodicity increases the peak-to-average load ratio for local utilities, which rely on quick-starting gas turbines or internal combustion engines to satisfy peak demand. Although many regions currently have surplus baseload capacity, strong growth in the residential sector will result in a need for more "peaking" capacity. Between 1998 and 2020, generating capacity from gas turbines and internal combustion engines is expected to more than triple.

Electricity demand in the commercial and industrial sectors grows by 1.2 and 1.3 percent a year, respectively, between 1998 and 2020. Annual commercial floorspace growth of 0.9 percent and industrial output growth of 1.8 percent contribute to the increase.

In addition to sectoral sales, cogenerators in 1998 produced 165 billion kilowatthours for their own use in industrial and commercial processes, such as petroleum refining and paper manufacturing. By 2020, cogenerators are expected to see only a slight decline in their share of total generation, increasing their own-use generation to 184 billion kilowatthours as the demand for manufactured products increases.

Retirements of Nuclear Capacity Could Lead to Higher Fossil Fuel Use

Figure 68. New generating capacity and retirements, 1998-2020 (gigawatts)



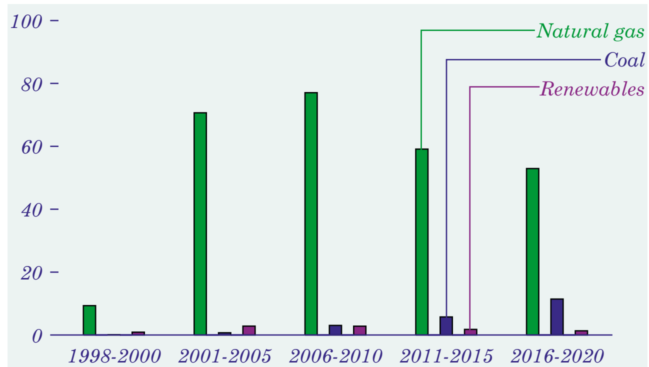
Despite slower demand growth, 300 gigawatts of new generating capacity will be needed by 2020 to meet growing demand and to replace retiring units. Between 1998 and 2020, 40 gigawatts (41 percent) of current nuclear capacity and 28 gigawatts (16 percent) of current oil- and gas-fired fossil-steam capacity [*65*] are expected to be retired. Of the 132 gigawatts of new capacity needed after 2010 (Figure 68), 21 percent will replace retired nuclear capacity.

The reduction in baseload nuclear capacity has a marked impact on the electricity outlook after 2010: 46 percent of the new combined-cycle and 82 percent of the new coal-fired capacity projected in the entire forecast are brought on line between 2010 and 2020. Before the advent of natural gas combined-cycle plants, fossil-fired baseload capacity additions were limited primarily to pulverized-coal steam units; however, efficiencies for combined-cycle units are expected to approach 54 percent by 2010, compared with 49 percent for coal-steam units, and the construction costs for combined-cycle units are only about 41 percent of those for coal-steam plants.

As older nuclear power plants age and their operating costs rise, more than 40 percent of currently operating nuclear capacity is expected to retire by 2020. More optimistic assumptions about operating lives and costs for nuclear units would reduce the need for new fossil-based capacity and reduce fossil fuel prices.

A Thousand New Generating Plants Could Be Needed by 2020

Figure 69. Electricity generation and cogeneration capacity additions by fuel type, 1998-2020 (gigawatts)

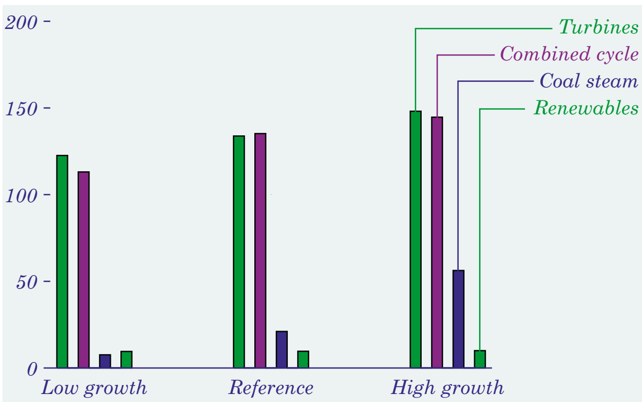


Before building new capacity, utilities are expected to use other options to meet demand growth—maintenance of existing plants, power imports from Canada and Mexico, and purchases from cogenerators. Even so, assuming an average plant capacity of 300 megawatts, a projected 1,000 new plants with a total of 300 gigawatts of capacity will be needed by 2020 to meet growing demand and to offset retirements. Of the new capacity, 90 percent is projected to be combined-cycle or combustion turbine technology fueled by natural gas or both oil and gas (Figure 69). Both technologies are designed primarily to supply peak and intermediate capacity, but combined-cycle technology can also be used to meet baseload requirements.

More than 21 gigawatts of new coal-fired capacity is projected to come on line between 1998 and 2020, accounting for almost 7 percent of all capacity expansion. Competition with low-cost gas-turbine-based technologies and the development of more efficient coal gasification systems have compelled vendors to standardize designs for coal-fired plants in efforts to reduce capital and operating costs in order to maintain a share of the market. Renewable technologies account for the remaining 3 percent of capacity expansion by 2020—primarily wind, biomass gasification, and municipal solid waste units. Oil-fired steam plants, with higher fuel costs and lower efficiencies, account for very little of the new capacity in the forecast. By 2020, annual investment in new capacity will be nearly $30 billion, assuming that the cost of new plants is recovered over a 20-year period.

Rapid Economic Growth Would Boost Advanced Coal-Fired Capacity

Figure 78. Cumulative new generating capacity by type in three cases, 1998-2020 (gigawatts)



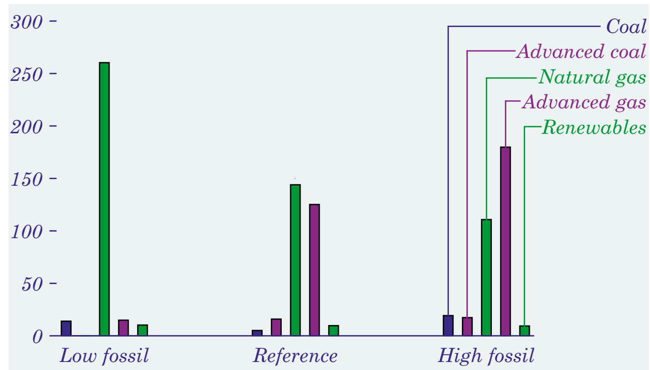
The annual average growth rate for GDP from 1998 to 2020 ranges from 2.6 percent in the high economic growth case to 1.7 percent in the low economic growth case. The difference of a percentage point in the economic growth rate leads to a 12-percent change in electricity demand in 2020, with a corresponding difference of 107 gigawatts of new capacity required in the high and low economic growth cases. Utilities are expected to retire about 12 percent of their current generating capacity (equivalent to 300 300-megawatt generating plants) by 2020 as the result of increased operating costs for aging plants.

Most of the new capacity needed in the high economic growth case beyond that added in the reference case is expected to consist of new advanced coal-fired plants, which make up more than 59 percent of the projected new capacity in the high growth case. The stronger growth also stimulates additions of gas-fired plants, which account for 40 percent of the capacity increase in the high economic growth case over that projected in the reference case (Figure 78).

Current construction costs for a typical plant range from $450 per kilowatt for combined-cycle technologies to $1,100 per kilowatt for coal-steam technologies. Those costs, along with the difficulty of obtaining permits and developing new generating sites, make refurbishment of existing power plants a profitable option in some cases. Between 1998 and 2020, utilities are expected to maintain most of their older coal-fired plants while retiring many of their older, higher cost oil- and gas-fired generating plants.

Gas-Fired Technologies Lead New Additions of Generating Capacity

Figure 79. Cumulative new electricity generating capacity by technology type in three cases, 1998-2020 (gigawatts)

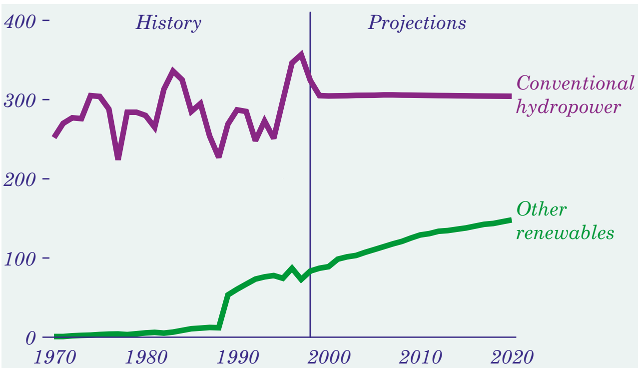


The *AEO2000* reference case uses the cost and performance characteristics of generating technologies to select the mix and amounts of new generating capacity for each year in the forecast. Numerical values for the characteristics of different technologies are determined in consultation with industry and government specialists. In the high fossil fuel case, capital costs, operating costs, and heat rates for advanced fossil-fired generating technologies (integrated coal gasification combined cycle, advanced combined cycle, advanced combustion turbine, and molten carbonate fuel cell) were revised to reflect potential improvements in costs and efficiencies as a result of accelerated research and development. The low fossil fuel case assumes that no advanced technologies will come on line during the projection period.

The basic story is the same in each of the three cases—gas technologies are expected to dominate new generating capacity additions (Figure 79). Across the cases the share of additions accounted for by gas technologies varies from 86 percent to 92 percent, and the mix between current and advanced gas technologies also varies across the cases. In the low fossil fuel case only 5 percent (15 gigawatts) of the gas plants added are advanced technology facilities, as compared with a 62-percent share (180 gigawatts) in the high fossil fuel case. Additions of coal-fired capacity increase slightly in the high fossil fuel case, but there is little change in additions of new renewable plants across the cases.

Renewable Generation Is Constrained by Relatively High Costs

Figure 80. Grid-connected electricity generation from renewable energy sources, 1970-2020 (billion kilowatthours)

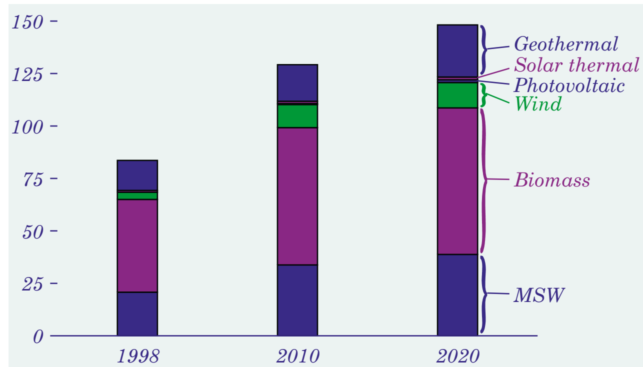


In the *AEO2000* reference case, projections are mixed for renewables in central station grid-connected U.S. electricity supply. State mandates produce substantial near-term growth for some renewable energy technologies, but generally higher costs are a disadvantage for renewables relative to fossil-fueled technologies over the forecast period as a whole. Total U.S. grid-connected electricity generation from renewable energy sources increases from 408 billion kilowatthours in 1998 to 452 billion kilowatthours in 2020, and generation from renewables other than hydroelectricity increases from 84 billion kilowatthours to 148 billion kilowatthours (Figure 80). Overall, renewables are projected to make up a smaller share of U.S. electricity generation, declining from 11.3 percent in 1998 to 9.5 percent in 2020.

Conventional hydroelectricity, which currently accounts for 80 percent of the electricity supply from renewables, declines slightly in the forecast. The expected addition of 620 megawatts of new capacity does not offset declines from existing hydroelectric facilities, as increasing environmental and other competing needs reduce their average productivity, and hydroelectric generation slips from 9.0 percent of the U.S. total in 1998 to 6.4 percent in 2020. The economic value of hydroelectric capacity is also likely to decline as environmental preferences shift generation to off-peak hours and seasons. If new legislation not assumed in the forecasts facilitates the removal of existing dams, hydroelectric generation will decline more sharply.

MSW and Biomass Lead the Increase in Renewable Fuel Use for Electricity

Figure 81. Nonhydroelectric renewable electricity generation by energy source, 1998, 2010, and 2020 (billion kilowatthours)



Most of the projected growth in renewable electricity generation is attributed to biomass, municipal solid waste (MSW), geothermal energy, and wind power (Figure 81). Generation from biomass and MSW increases the most, from a combined total of 65 billion kilowatthours in 1998 to 109 billion in 2020. Generation from biomass, particularly in the pulp and paper industries, grows by nearly 26 billion kilowatthours through 2020, more than half of which is from industrial cogeneration and the remainder either from plants using biomass strictly for electricity generation or from biomass co-firing in coal-fired plants, as co-firing is used increasingly to reduce emissions. Dedicated biomass-consuming capacity, with higher capital and fuel costs than fossil-fueled technologies, increases by only 1.2 gigawatts.

U.S. wind-powered generating capacity increased by a total of nearly 860 megawatts in 1998 and 1999, spurred by the now-expired Federal production tax credit. State mandates are estimated to yield nearly 2,400 megawatts of additional new wind capacity from 1999 through 2010, and more than 400 additional megawatts through 2020. Nevertheless, higher capital costs, lower output per kilowatt, and limited predictability put wind power at a disadvantage relative to natural gas and coal technologies.

Geothermal energy capacity is projected to increase by 860 megawatts between 1998 and 2020, contributing an additional 10 billion kilowatthours of generation in 2020. Solar technologies are not expected to add significantly to central station power generation, but off-grid and distributed applications for photovoltaics should continue robust growth.